# Response to a Trial of Physician-Based Inpatient Order Entry

Jonathan M. Teich, Cynthia D. Spurr, Steven J. Flammini, Jennifer Schmiz,
Robert F. Beckley, Jean F. Hurley, Meg Aranow, and John P. Glaser
Department of Information Systems, Brigham and Women's Hospital, Boston, MA

## ABSTRACT

*Our group has developed a physician-operated inpatient order-entry system (BICS-OE). Mindful of the problems inherent in bringing a radical cultural change such as this to the hospital, we conducted two pilots of the system prior to its full implementation. Physicians and nurses both identified a number of benefits from the use of OE. Physicians reported a number of areas where OE use was difficult or could be improved; nurses reported fewer problems. Based on the pilot trials, we modified the interface and some data constructs. These changes have enhanced the usefulness of OE in patient care in our hospital, and can serve as a model to others developing order entry.*

## INTRODUCTION

The Brigham Integrated Computing System (BICS) provides a broad range of clinical and administrative data-management functions for Brigham and Women's Hospital (BWH), a 750-bed major urban teaching hospital. BICS is a descendant of the hospital computing system at Beth Israel Hospital [1]; functions and interface derived from this system are still operating in a number of areas. Independent development has proceeded at BWH since 1988. Over the past three years, the system has been converted to a 2000-microcomputer network which offers increased computing power and functionality. ANSI Standard MUMPS and a windowing interface (Hyper-M) are used in new projects.

Our group designed a physician-based order entry system to handle all inpatient orders. There are many reasons to develop BICS-OE; among the presumed gains are decreased order turnaround time, fewer handling and transcription errors, greater legibility, and fewer missed orders. Orders flow directly into worksheets for order processing areas, and into upcoming Kardex and MAR subsystems. BICS-OE is also an important component in our current development of advanced decision support systems for BICS. The order is a direct indication of the physician's current decision state and can be used to trigger rules and algorithms. The computer can also supply direct feedback and alerts to the physician while the order is still being written [2].

Past reports about order entry systems have described great difficulty in introducing the system to physicians [3,4,5]. Complaints about excessive time spent on ordering, lack of collaboration, and poor order review functions have been reported. We sought to avoid acceptance problems by observing other systems' perceived good and bad points, and by consulting potential users throughout the design process. The design of the order entry system, and its unique aspects, are described elsewhere [6].

## PILOT STUDIES

Realizing that many problems would show up only in actual use, we arranged two two-week pilot tests of BICS-OE once it was built. The first pilot was performed on a specialty unit (bone marrow transplant) with a small staff and little patient turnaround. After assessing and responding to this pilot, the second was performed on a general medicine unit with much more diversity of patients and staff.

Feedback was obtained in several ways. Nurse specialists from the OE team served as trainers and observers, noting the activities of the physicians, nurses, and secretaries on the floor. OE team members met with the users regularly to inquire about pluses and minuses. A "feedback" option on the menu bar allowed users to register comments directly. Finally, meetings were held with users at the end of the pilot, allowing more organized input. The primary OE design team, including several information systems members as well as a doctor, a nurse, and a pharmacist, reviewed all feedback and designed system changes as needed.

We describe here the main user impressions from the pilot, and the changes which were made as a result.

## PERCEIVED ADVANTAGES

The potential advantages of OE listed above are advantages to the hospital and to the care of the patient. It is important, however, to provide direct benefits to the physician writing the orders.

In our hospital, all ordering is done by residents. The residents in the pilot listed these as the most important direct advantages of using OE:

1. Being able to write orders on any patient from any location. Residents did not have to return after work rounds to write the orders for the OE unit.
2. Display of suggested doses and frequencies for a medication.

0195-4210/92/$5.00 

3. Display, and direct editing, of pending lab orders for the next week.
4. Automatic display of relevant lab results when ordering a medication.
5. Easy access to related orders, such as standard premedications for blood transfusions, or peak and trough levels for aminoglycosides.
6. Easy entry of total parenteral nutrition (TPN) orders. OE keeps the last day's parameters on-line, and calculates electrolyte components for the physician.
7. Departmental order sets and templates, which speed ordering in common situations.
8. Documentation that the nurse has seen and "taken off" (acknowledged) the order.

For nurses, favorite features included:

1. Fewer voice orders. When a doctor was paged because of some new information, the doctor could enter any needed orders from the nearest workstation.
2. Easy lookup of past orders and patient results.
3. Legibility of orders.

The unit secretary had a favorable response to the system as well. In particular, consult requests all had reasonable clinical information on them. Also, they were freed from the task of going through all inpatient charts at night to gather the lab test requests for the morning; instead, the set of morning lab tests for the unit was present on-line and could be printed at any time.

In general, the pilot users felt that the system was usable and that most ordering was straightforward. They recognized the direct benefits well enough to be able to request others, and understood the benefits to patient care.

## PERCEIVED DISADVANTAGES

Nurses found the system very acceptable as a replacement for paper systems. As predicted, physicians cited more disadvantages. These concerns centered around difficulty in ordering complex orders, and the speed and efficiency of writing simple orders. The following items were recognized by users as problematic:

1. The process of going to the nearest workstation, signing on, entering the patient identifier and beginning OE was thought to be tedious. Complaints about these steps would probably lessen as users became familiar with them; staff realized that in paper ordering they needed to go to the patient's floor, find the patient's chart and turn to the ordering section, but this had become an unconscious process. Difficulties due primarily to change must be recognized and addressed if a new system is to succeed.
2. Some complex orders were difficult to enter. The most common of these were medication dose variations: sliding scales, titrations, tapers, alternating and variable doses, bolus plus infusion, and sequential orders (for example, progressive diet orders written in advance, or loading plus maintenance doses). Physicians generally resorted to writing complex instructions, which would not be coded properly.
3. As-yet-unsigned orders entered during the current session (said to be in the order scratchpad) were too hard to view, change, and remove. They also needed to be active for order-conflict purposes.
4. Conversely, some orders were too easy to enter. As designed, one could repeat the previous day's TPN orders simply by entering the TPN area and pressing Enter. Users occasionally pressed Enter inadvertently, thus entering an incomplete or unwanted order into the session scratchpad. The same was true for the first generation of templates.
5. Users who had missed the training sessions were unaware of how to enter orders that did not fit any category (a subsection under General Care).
6. The display of entered orders was not in a familiar format, although the same information was present.
7. The text-mode parser sometimes offered interpretations of orders that seemed bizarre to the physician (see below).

## DESIGN MODIFICATIONS

The OE development team reviewed the problems with the physician and nurse user groups during and after the pilot. The specific concerns caused us to reassess standard assumptions about ordering behavior. We present some of the changes made as models for other OE development efforts.

### Scratchpad

The scratchpad contains the orders which have been entered during the current session, but which have not yet been signed. The scratchpad takes on special importance in a system such as ours, where we seek to provide feedback to the physicians concerning conflicts and interactions among orders [8].

Essentially, scratchpad orders should be considered as having actually been ordered, for purposes of conflicts and edits with other orders in the

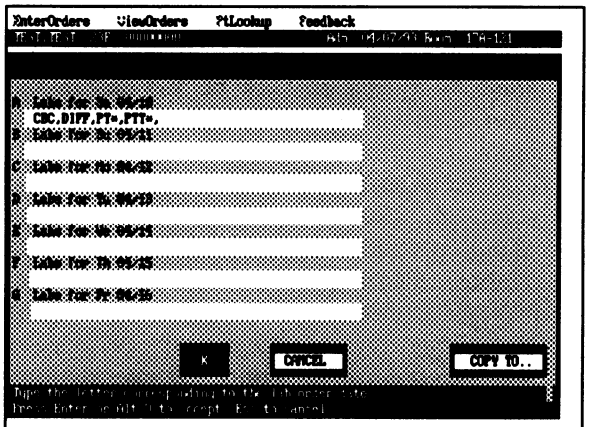


Figure 1. The multi-day lab ordering screen.

same session. For example, if a user enters an order stating that a patient is allergic to penicillins, and then enters an order for amoxicillin, that should generate an allergy conflict even though the first order has not yet been signed. More frequently, the scratchpad helps avoid spurious conflicts. If a patient is on ibuprofen and is ordered for indomethacin, OE can display a same-class advisory. But if the sequence of orders in the scratchpad is "D/C ibuprofen" followed by an order for indomethacin -- a common occurrence -- then the advisory should not be displayed. In lab ordering, any lab test in the scratchpad should be displayed in the multi-day lab order screen, along with the signed pending lab orders.(Fig. 1).

Finally, scratchpad orders can be mutually exclusive in ways that signed orders are not. If a diet order is entered and then another diet (with the same start time) is entered during the same session, that is an error and needs to be reported.

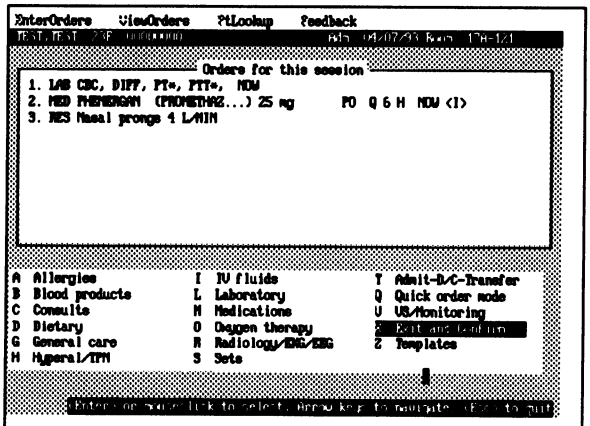


Figure 2. The scratchpad can be viewed during the order session. Editing or deletions can be made from the same screen.

The OE system was changed so that (a) the scratchpad is readily visible during an order session, (b) scratchpad orders can be modified or removed before entering the confirmation screen (Fig. 2), and (c) these orders are live for the purposes of conflict checking.

**Interface Modifications**

Substantial changes to the user interface were not needed. As mentioned above, there is a balance that must be struck for best user interaction. Common orders should be entered with maximum speed and minimum annoyance. At the same time, there should be enough flexibility to permit a full range of parameters.

**Synonyms.** OE allows commonly-used synonyms for many medications, procedures, and test names. The synonym facility has been expanded to allow a single synonym to apply to different items depending on usage. For example, "Clindamycin" refers to two different medications in our formulary: clindamycin hydrochloride (when used orally) and clindamycin phosphate (when used IV). OE also tries to steer the user to the most appropriate choice -- thus, "Insulin" will display all forms of insulin, but the pointer will rest on human insulin, the standard choice. This technique can also be used to direct users with no preference to less expensive treatments, as demonstrated by Tierney [2].

**Quick access.** The access menus were weighted for the fact that some menu choices are used far more frequently than others. When a doctor or nurse logs on, the appropriate patient list is displayed, and patient lookup/ordering choices appear first. Other standard functions from the original menu are now pushbuttons on the screen. The number of steps required to log in to a workstation and reach a patient's lookup or order entry area has been reduced from six to two (three if the desired patient is not on the primary list). Since BICS automatically maintains each doctor's personal patient list, the probability of finding the desired patient on the first display is high. For nurses, the personal patient list is replaced by a display of the current unit's patients.

To speed ordering in most areas, the "Ok" button is made the default; pressing Enter takes the order as constructed (after checking for completeness). In areas such as templates, where complex orders could be entered too easily, this default is removed.

To aid the user in finding nonspecific general-care orders, a "Miscellaneous" order type has been added.

**Complex doses.** Sliding scales for specific medications (potassium, magnesium, nitroglycerin paste, and insulin) are provided as specialized windows when that dosage form is chosen. Other windows handle titrations, tapers, alternating and variable doses. Initial boluses and loading doses are pushbuttons on the medication order screen; access to these is not required but is always available.

**View.** The format for displaying orders was changed to a more relaxed style that closely resembles the style of handwritten orders while retaining all information. Orders were grouped by session, so that the name of the doctor, nurse, student, etc., could appear fewer times in the display while still being clearly identifiable.

### Times

Most orders offer a default time and a choice of likely other times. For example, for lab tests the default is "routine" (next phlebotomy rounds for blood tests, do when possible for other tests). Alternative on-screen choices are "stat", "drawn by MD/RN" and "in AM". BICS-OE accepts a wide range of other times for orders via a general time window. Times entered here are parsed by the text-mode parser, which can handle complex expressions such as "on Thursday after cardiac cath".

BICS-OE provides on-line renewal of medications, oxygen, and do-not-resuscitate orders. A renewal time is calculated for each order based on hospital policy, and the physician is advised if renewals are due. End times are also calculated for orders that have them (e.g., "Rifampin 600 mg po bid x 2 days") so that the order can be removed from active status. This is vital to the support of the MAR and to conflict checking.

### Text Mode

The text-mode parser [6] permits quick entry of a wide range of orders. It had originally been designed to allow maximum flexibility: key tokens which defined an order could appear in any sequence, even be misspelled, and the parser would search for possible meanings. However, as a result, when orders were entered with many words of instructions, the parser would spend a great deal of effort searching for all possible words that could be a misspelled key token. An order involving the use of absorbent cotton for a dressing could generate a possible match to codeine (Soundex match to cotton) which would be perplexing to the user.

This difficulty was addressed in three ways. All text mode orders were stored as typed for development purposes. We used this data to generate a list of tokens which are to be used to guide the interpretation ("Lab:"). The parser also now checks a standard English dictionary in real time to find words which are probably non-medical terms, rather than misspelled keywords. Finally, the Soundex algorithm is not applied to typed words of four letters or less, nor will it find dictionary tokens of four letters or less.

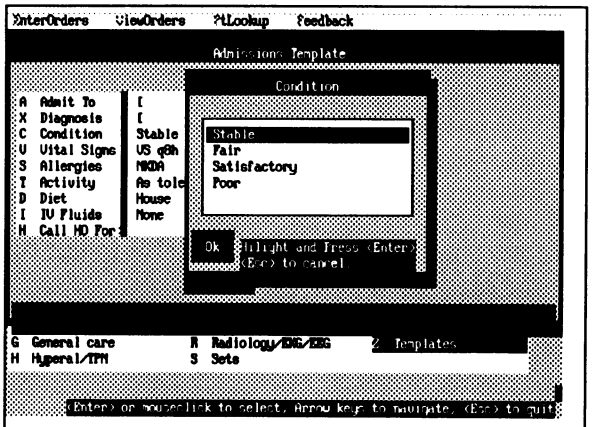


Figure 3. The admission template allows rapid entry of diverse orders.

### Protocols, Templates, and Order Sets

BICS-OE supports personal order sets, usable only by the author; departmental order sets, usable by anyone but restricted in creation and editing; and templates, which are individual screens providing fixed and optional orders for a particular clinical situation. Creating order sets has been made easier and more consistent with the rest of the interface.

Templates serve many purposes. They can be used to replace the many paper protocols present at our hospital. Multi-day protocols are broken into individual days; if a day needs to be postponed or advanced, the template can stay accurate.

Templates speed ordering in areas where many diverse orders are required, such as a patient admission (Fig. 3). Templates are also important to decision support: each patient can have standing templates which are used in conjunction with patient care algorithms. These can be initiated at the physician's request, or they can be triggered by entries in the problem list or the admission diagnosis.

### Nursing Interface

The unit monitor displays those patients who have pending orders for nursing. The monitor also receives and displays alerts and bed-control information. In response to pilot feedback, the monitor now has different display indicators for

pending stat orders, patients whose orders have been held, and patients who have requisitions and other orders for the unit secretary to process.

**Printing.** Orders are not automatically printed, except for the final medical record. We allow on-demand printing of any group of orders. On the first pilot unit, nurses often printed out an order when they were not familiar with the display format on screen; they also liked using a printout of the day's orders to guide them as they signed out to the next shift. On the second pilot unit, the display was clear enough that frequent session printing was not necessary; printing was mainly used to make a copy of orders that needed physician clarification.

Voice orders still exist under computer OE, mainly for physicians who are in the operating room or otherwise unable to get to a workstation. When a nurse writes and signs an order, the computer asks for the name of the physician who gave the order, and also asks if the nurse wishes to take off the order at the same time.

At nurses' request, two additional order types were added for nursing use: "Please send" orders transmit requests for additional products from the pharmacy. "24-hour check" orders certify that a nurse has reviewed the orders for the day and has determined that none have gone unacknowledged. This order is presumably unnecessary, since the monitor would display any unacknowledged orders; however, the nursing staff requested it as additional documentation.

### Adding Additional Value

Based on observation of physician and nurse behavior during the pilot, several new features have been added to BICS-OE to provide increased value and benefit to patient care. For example, physicians are alerted by BICS-OE for clinical events, orders that need cosigning or renewal, and incomplete sessions. The physician can enter a "move-up" request to radiology while ordering procedures such as CT scans, if they must be performed earlier than routine scheduling would provide. This saves time and phone calls. A new chemotherapy template performs body-surface-area calculations and converts meters-squared dose to absolute dose for the pharmacy.

## CONCLUSIONS

To realize the many benefits to patient care which can result from physician order entry, it is vital to create a system which provides direct benefits and few disadvantages to the front-line doctors and nurses. The pilot tests of BICS-OE revealed important details of actual ordering behavior; physicians called for both faster ordering of common orders and more flexible ordering variations. By collaborating with the users, responding to their feedback, and providing functions with additional clinical value, we have been able to improve the value of the OE system to patient care and increase its acceptance among our staff.

In the coming year we plan to extend OE to encompass all hospital inpatient services, to implement more workflow support tools for nursing and ancillary areas, and to add more intensive decision support and informational resources to the ordering process. As we make each of these developments, we will continue to rely on user feedback to complete the connection between design and practice.

## Reference


1. Bleich HL, Beckley RF, et. al., "Clinical Computing in a Teaching Hospital," *New Eng. J. Med.* **312**(12), 1985, pp. 756-64.

2. Tierney WM, Miller ME, Overhage JM, McDonald CJ, "Physician Inpatient Order Writing on Microcomputer Workstations," *JAMA* **269**(3), 1993, pp. 379-383.

3. Aydin CE, and Ischar R, "The Effects of Computerized Order Entry on Communication between Pharmacy and Nursing," *Proc. SCAMC,* **13,** 1989, pp. 796-800

4. Massaro TA, "Introducing Physician Order Entry at a Major Academic Medical Center", *Academic Medicine* **68**(1), 1993, pp. 20-30.

5. Anderson JG, and Jay SJ, "Why Doctors Don't Use Computers: Some Empirical Findings," in Anderson (ed.) *Use and Impact of Computers in Clinical Medicine*, Springer Verlag, 1987.

6. Teich JM, Hurley JF, Beckley RF, Aranow, MA, "Design of an Easy-to-Use Physician Order Entry System with Support for Nursing and Ancillary Departments," *Proc. SCAMC,* **16**, 1992, pp. 99-103.

7. Malbin K, Putz B, et. al., "The Process and Outcome of a Collaborative Effort to Design and Implement a Clinician Order Processing System," *Proc. SCAMC,* **16**, 1992, pp. 785-786.

8. Lepage EF, Gardner RM, Laub RM, Jacobson JT, "Assessing the Effectiveness of a Computerized Blood Order "Consultation" System," *Proc. SCAMC,* **15**, 1991, pp. 33-37.